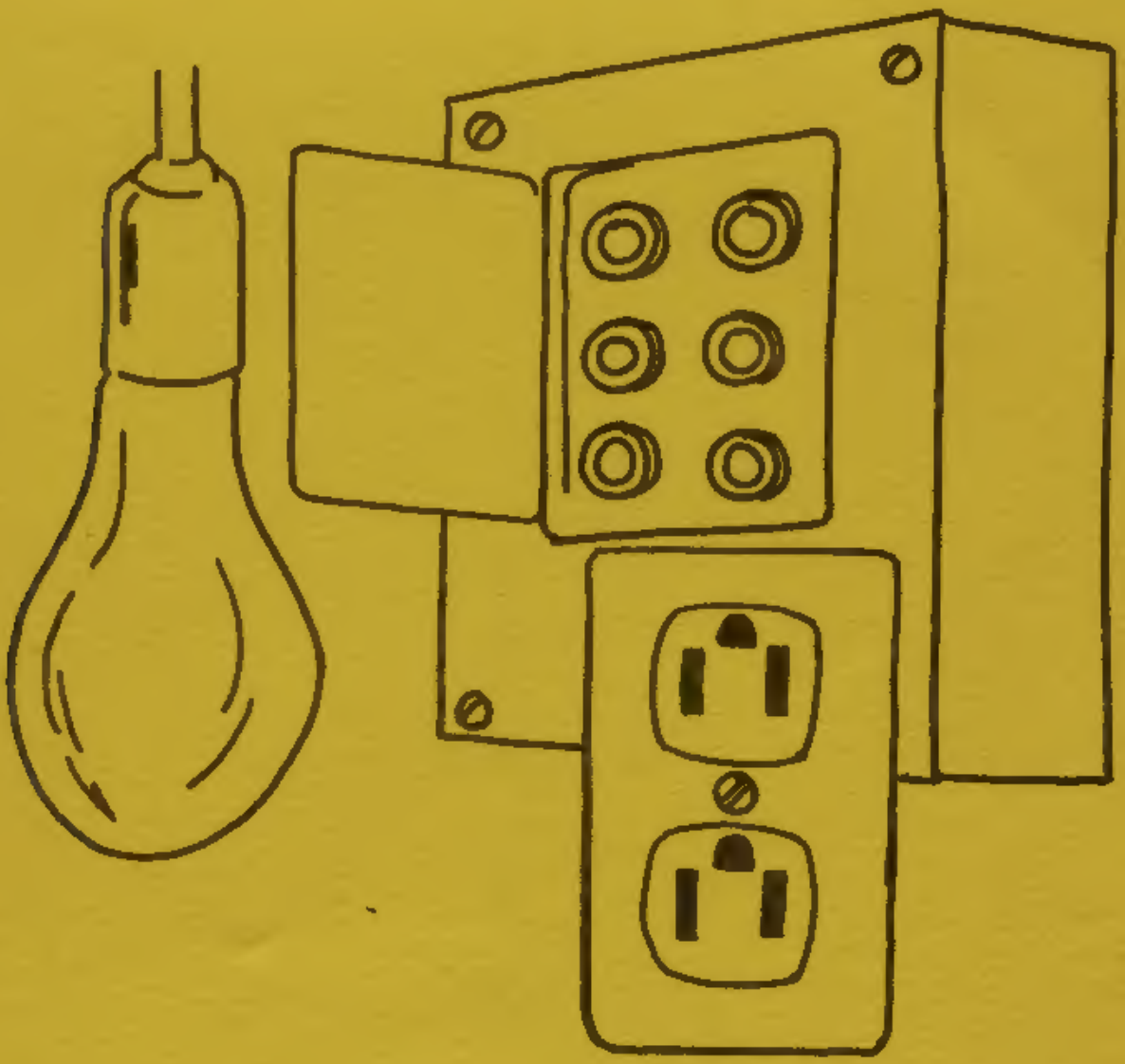
ELECTRICAL



SESSION I

newark
redevelopment &
housing authority

HOMEOWNERS TRAINING COURSE

AT

NEWARK REDEVELOPMENT AND HOUSING AUTHORITY

MAINTENANCE TRAINING CENTER

4 Sheffield Drive

Newark, N.J. 07104

Saturday, December 3, 1977

9:00 a.m. - 1:00 p.m.

Instructor: Bernard Chelis

E L E C T R I C A L

Session #1

1. Safety
2. Basic theory - (series - parallel)
3. House wiring systems - 2-wire, 3-wire
4. Over current - protection
5. Trouble shooting for the homeowner
6. Identification of material, devices and tools
7. Wiring methods
8. Switch installation
9. Outlet installation
10. Fixture installation

Safety

Play It Safe

Caution, common sense and proper grounding technique will prevent needless accidents.

Play it safe. It's easy to do so by following a few, common sense simple rules.

It would appear at first sight that the easiest way to avoid shock, when making repairs or installing new equipment, is merely to yank open the main switch. This deactivates all the wiring in the house and therefore you can touch anything with complete safety. This move is practicable if the work will take only a few minutes; say up to about 15 or 20. You must remember that pulling the main switch removes power from the kitchen refrigerator (and food freezer), which might be undesirable in warm weather; and also shuts down any modern heating plant, which might be undesirable in cold weather. With the main switch off you have no electric light, so you can work only in daylight in an area near a window.

Although an open main switch gives 200% safety, you can still have 100% safety, and the convenience of power for light, tools, etc., by removing the branch fuse only for the circuit that you want to touch. Presumably you

have identified all the fuse or circuit breaker positions, so this should take only a moment. Don't merely loosen the fuse in its socket; unscrew it completely and place it on the fuse box. Inform the other members of the family present in the house as to just what you are doing, and what outlets, lights, etc., will be inoperative while you are doing it.

With the line presumably opened by the fuse or breaker, give it a double check with the Lightester. If the bulb of the latter doesn't light, you can proceed.

Basic Electricity

Introduction

When we say electricity, what do we mean? Electricity is broken down into four basic units. The four being:

(A) Volt - The amount of pressure

(B) Amphere - the amount of flow

(C) Ohm - the amount of resistance

(D) Watt - the amount of power needed or consumed

These items constitute all we will really need to know at this time.

The most common type of electrical current supplied by the utility companies is alternating current or A.C. transmitted over long distances with a minimum of loss, thus giving more efficiency to the system.

One must remember that whenever or wherever electricity is concerned we always have an electrical code that must be adhered too. If we follow the code exactly, then there will never be any mistakes or accidents. Some areas require that only a licensed electrician be able to do some repairs or installations. So, check on this before you start anything pertaining to electricity.

Electrical System

The Two-Wire House System

The majority of small houses built prior to the television and electric appliance boom of the post-World War II period are fed with a simple, basic two-wire power system. Two wires, running from the nearest secondary distribution transformer, enter the house. They might be suspended aerially from a pole on the curb line, or they might be completely out of sight in buried pipe. With such a two-wire service, the voltage is always "115." One wire has white or gray colored insulation. It is connected to the nearest water pipe and is called the "ground" wire. The second wire has black insulation and is called the "hot" side of the line only to distinguish it from the other. The grounded wire is by no means "cold" by implication; the two wires can function only together, not separately. Standard practice is to keep the grounded wire a continuous circuit throughout the house, and to insert fuses and switches only in the hot wire.

The main switch and the main fuse are usually in a single steel box. The cover of the latter is linked to the switch handle in such a manner that the fuse is accessible inside only when the switch is thrown to "off." With the switch open or the fuse burned out, the entire electrical system of the house is dead.

The watt-hour meter registers the power consumed in the house. Following it, there are usually several individual "branch" circuits, each with a fuse. These feed power to various parts of the house. If the builder was conscientious, he arranged the branch circuits so that the ceiling lights and the wall outlets in the rooms are on different branches. Thus, if an appliance plugged into a wall outlet blows a fuse, the room lights still work. It is also sensible to provide individual lines for outlets that require a lot of current: one is the kitchen for instance, for an iron or toaster, and another in the basement for a washing machine.

Electrical terms and their meaning

In order for electricity to travel through wiring, it has to be under pressure–much the same way water is under pressure in your plumbing system. This electrical pressure is measured in **volts** or **voltage.** Modern homes receive 240 volts of electrical power. This power enters the home through an electrical service entrance and passes through a meter where the amount that the household uses is measured and distributed throughout the house. Most appliances operate on 120-volt current; heavy-duty appliances such as an electric range or oven, clothes washer or dryer require 240 volts.

The amount of electricity that can be delivered to an appliance or group of appliances is limited by the diameter of the wire that it must flow through. The term for this measurement is **amperes.** Just as a larger diameter pipe can deliver more water, a larger wire is required to conduct a greater amount of electricity. The fuse size must be matched to the wire size so that if necessary the fuse will blow before the wire overheats and causes a fire hazard.

The wiring that travels through the walls and ceilings of a house is divided into **circuits.** Each circuit connects with a series of wall outlets and switches. Each heavy-duty appliance has its own separate circuit. Every household circuit is protected by a **fuse** or a **circuit breaker.** These devices break (or interrupt) the circuit when it is overloaded.

The number of electrical circuits in a house determines how many electrical appliances you can use conveniently and safely. If your home is over 20 years old and has never been rewired, it undoubtedly needs improvements in its wiring system.

What to look for

Buying a new home: Check the size of the electric service wires and the electric service panel. An ideal service is 3-wire 150- to 200-ampere (wire of suitable size). A home equipped with an electric range, hot-water heater, dryer, and central air conditioning, along with the usual lighting and appliances, needs a 150-ampere service as a minimum. With electric heating, the need increases to 200 amperes.

Buying an old home: Check the capacity of the electric service panel. A home with a 3-wire service is more valuable than one with two wires. The information on the following pages will help you to calculate your needs and make a more informed decision.

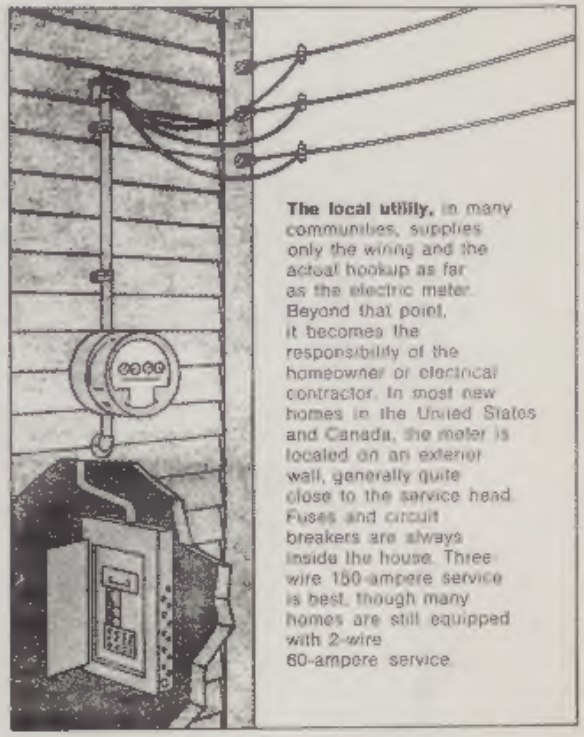
Appraising the wiring in an existing home: The great majority—an estimated 90 percent—of the nation's homes need some rewiring. If your electrical system displays any of the symptoms described on the following page, use this section as the basis for a review of your requirements with an electrical contractor.

How to read a meter

When the needle is between two numbers, always read the lower number. The dials in this illustration, for example, read 8187. The needle for each dial must have reached a number before you read that number. Note that the needle for the second dial from the left has passed the 1 mark but has not reached the 2.

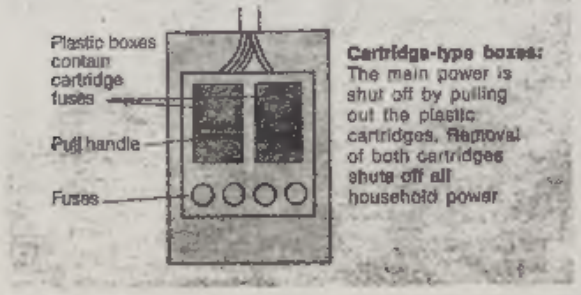
Hookup from power lines

Never attempt to work on the electric power hookup entering the house. These wires carry high voltage and are dangerous. Should they become damaged or worn, call your power company to make repairs.

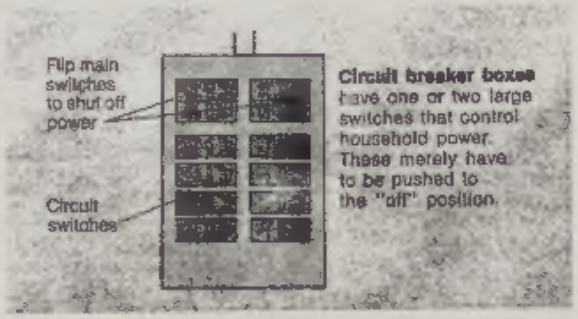


The local utility, in many communities, supplies only the wiring and the actual hookup as far as the electric meter. Beyond that point, it becomes the responsibility of the homeowner or electrical contractor. In most new homes in the United States and Canada, the meter is located on an exterior wall, generally quite close to the service head. Fuses and circuit breakers are always inside the house. Three-wire 150-ampere service is best, though many homes are still equipped with 2-wire 60-ampere service.

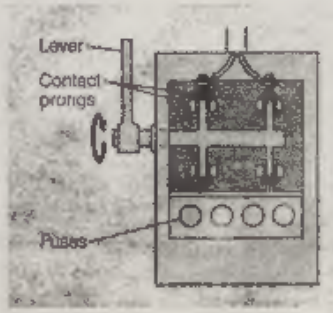
How to shut off main power



Cartridge-type boxes: The main power is shut off by pulling out the plastic cartridges. Removal of both cartridges shuts off all household power.



Circuit breaker boxes have one or two large switches that control household power. These merely have to be pushed to the "off" position.



Lever-type switches are usually found in older wiring installations as the main power switch. Lifting (or pulling) the lever to the "off" position will cut the main power supply.

Fuses And Circuit Breakers

WHEN THE LIGHTS GO OUT- the fuses or circuit breakers have been overloaded. The only cure is to lighten the load, not to invest in larger protective devices.

If fuses keep blowing out, merely replacing them with new ones is no cure for the overload somewhere in the house that is causing them to go "pfft." And replacing the original fuses with others of higher amperage rating is about as sensible as looking for a gas leak with a candle.

In some homes, in which no new heavy-current appliances have been added recently and everything is working satisfactorily, a fuse may go dead without apparent reason, and putting in a new one of the same rating restores operation to normal. In cases of this kind the original fuse itself was probably faulty. It may not have burned out at all, but merely developed an internal open circuit. The fuse wire may have become brittle and then broken under the influence of vibration from a passing truck, a slamming door etc. I have examined many fuses that looked perfectly good yet showed positively and unquestionably as complete "opens" when given a continuity check.

Sometimes a fuse definitely blows out, and replacing it restores normal conditions. The burn-out may well have been due to a momentary short circuit which cleared itself, at least for the time being. For instance, a few strands of the flexible wire inside a cord for a floor lamp, a TV set,

a fan, etc., might have worked against themselves because the cord has been stepped on a lot or otherwise abused. Enough current may have flown across these wires, during a second or so, to heat them and the fuse in the same circuit to the melting point. A new fuse holds, although the cord remains potentially dangerous.

Sometimes the touching wires, instead of flaring open, weld themselves together. New fuses then burn out as quickly as you put them in. Actually, it is better for this to happen, as then you know something is definitely haywire someplace and you are forced to go looking for it.

As a general practice, when trouble-shooting the house power circuits, allow yourself one new fuse as a replacement for a blown unit. If this pops off, start shooting!

Standard "plug" fuses have bases like lamps, and screw into receptacles in "cut-out" box. Keep a record on cover of latter of house circuits controlled by particular fuses to ease replacement.

"Cartridge" type fuses have exposed metal end caps, which fit tightly in spring clips in cutout box. Keep spares in latter. CAUTION: Even if fuse is blown out, end cap on side to meter is still "hot."

Fuses And Circuit Breakers

Chart of Fuse Positions

The "cut out" box in most homes contains six fuses; more in many newer houses. It is highly advisable to know which fuses control which outlets and lights all through the dwelling. Have an assistant turn on all the lights in one room at a time, and also activate the wall outlets with portable lamps, a radio set, etc. Start removing fuses and let the assistant shout down or stamp on the cover of the fuse box. Also, keep a handful of spare fuses, of the right sizes for your power installation, within easy reach of the fuse box. You'll congratulate yourself on your foresight in this regard the very first time a circuit goes dead unexpectedly, as it always does.

Circuit Breakers

In all but the lowest price brackets, the tendency in new home construction is now definitely toward the use of circuit breakers rather than fuses for protection against excessive current surges. A circuit breaker has a handle like a switch and looks very much like one; it is in fact a self-tripping switch that goes open when the current passing through it exceeds its rated value.

The breakers now coming into home use work on either a thermal or a magnetic effect, or a combination of the two.

The thermal type employs a bi-metallic strip which flexes and trips one or more sets of spring-loaded contact points when the rated current value is passed. The magnetic type contains an electromagnet which does the same job. Most breakers incorporate a time delay feature like that of slow-blow fuses, and for exactly the same reason.

When a circuit breaker trips open on an overload, it can be reset in an instant; you merely push the handle back up. If the overload is still on, it will trip again. Like a good switch, a breaker will last a long time and rarely if ever will require replacement.

Because circuit breakers cost from 4 to about 25 times more than fuses, many people have gotten the impression that circuit breakers in general have magical properties and offer more protection than fuses do. This is not so. An overload that trips a $2.50 breaker will also burn out a five-cent fuse, and just as quickly and thoroughly. The most obvious advantage of breakers is convenience. A far more important feature, which is not as widely appreciated as it should be, is that in many cases they prevent a thoughtless homeowner from deliberately overloading his power lines.

Consider a "standard" house having branch circuits protected by regular 15-ampere plug fuses. A new table-top broiler arrives one day and all the members of the family gather round while it is unpacked, admired, and then, of course, plugged into see how it works. Many such broilers

Take pretty close to 15-amps all by themselves. If current is being carried on the same line for lights or other purposes, there is a very good chance that the 15 amp fuse will evaporate. Great disappointment registers on the faces of mother and kids. So what does pop do? Nine times out of ten, he will not resist the temptation to replace the 15 amp safety valve with a 20-amp plug. Result the broiler goes on and his reputation as Mr. Fix It is saved. What happens to the power line is another story. Sooner or later this practice leads to disaster.

If the house is equipped with 15-ampere circuit breakers, the breaker feeding the broiler line will flip open on the overload just as the fuse did. But this breaker is permanently bolted into the distribution box, with its connections out of sight. There's nothing you can do to it except push the handle back to "on". Every time it trips open it is warning you that the broiler is just too much for that line. You might swear at it a little, but the sooner you realize the significance of the tripping of a circuit breaker, the longer will your house last.

I have heard people say they don't like circuit breakers because "they don't allow any flexibility in operating certain lines in the house." The fact that breakers do not permit any such "flexibility" is the greatest argument in their favor. Probably 90% of all actual cases of fires, charred wiring,

sluggish air conditio[illegible] no freez[illegible], etc., would not have occurred at all if uncorruptible breakers had been used instead of e[illegible]ily "fixed" fuses, which are a danger in ignorant hands.

In this section the value of 15 ampere has been used in describing fuse and breaker protection for branch circuits in a house. This is the safe allowable carrying capacity of No. 14 wire, the s[illegible] commonly used in homes. However, much greater values are permissible with heavier wires. But remember, an overload is an overload, regardless.

Fuses and circuit breakers

The job they do

Fuses and circuit breakers might be called the watchmen of your electrical system. When a fuse blows or a circuit breaker trips, it is telling you that something is wrong. What is wrong may be two bare elec-

many appliances on the same circuit. If a when you push down the toaster handle, there is a good chance that you may be operating, say, a broiler or an electric iron on the same circuit. If you are unplug the iron or broiler and then replace the fuse or reset the circuit breaker.

A fuse that has been ba by a short circuit will usually have a blackened or discolored mica window. A fuse that has blown because of an overload will usually show a clear window, but there will be a break in the flat metal strip. The circuit breaker just

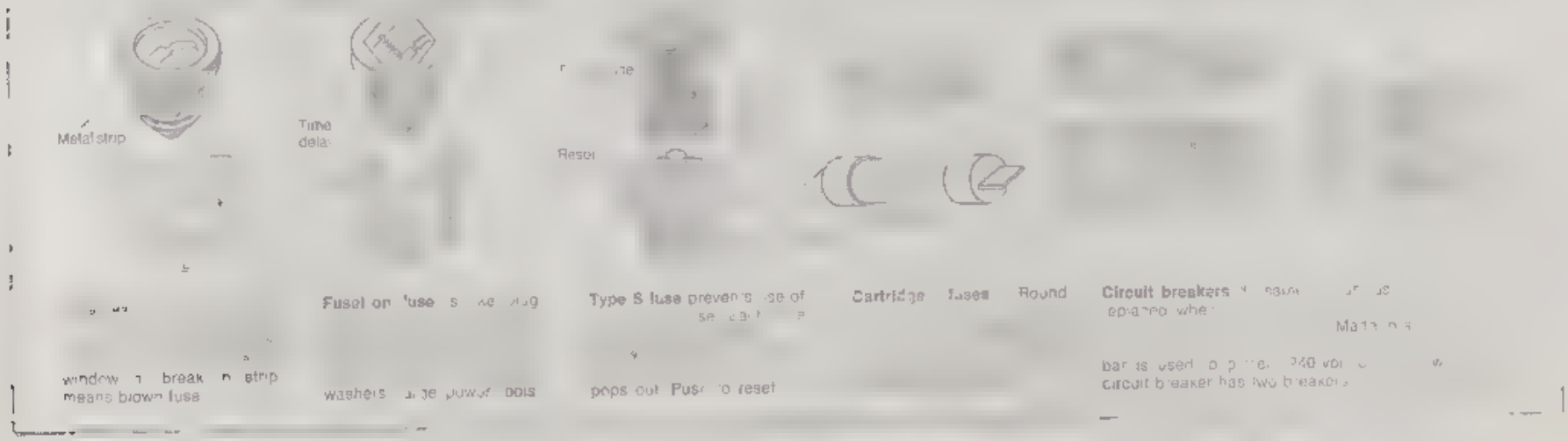
overload or s

It is practical to keep spare fuses handy near the fuse box. When you replace a fuse, be sure that the new one is of the same capacity. In other words, if you blow a 15-ampere fuse, replace it with a 15-ampere fuse, never a 20 or 2

Fuse box with the main disconnect at top

Circuit breaker with handle in

Types of fuses and circuit breakers



Fuse or fuse s ... plug

window in break in strip means blown fuse

Type S fuse prevents use of ...

washers ... large power tools

Cartridge fuses Round ...

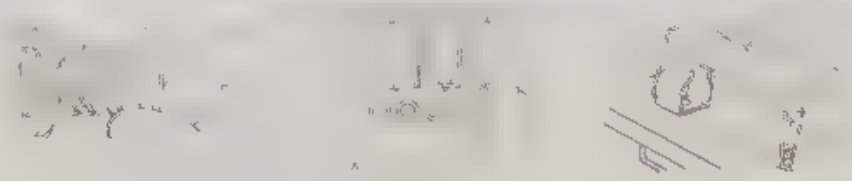
pops out. Push to reset

Circuit breakers ... replaced when ...

Main ... bar is used to protect 240 volt ... circuit breaker has two breakers ...

How to replace a blown fuse

Remove the fuse by turning it counterclockwise (first shut off the main switch). If it is a 15-ampere fuse, make sure the replacement is the same. Pull a cartridge type fuse straight out. Large ones are best handled with a fuse puller. To "replace" a tripped circuit breaker, push the toggle handle to the full "on." Always be sure your feet are on a dry surface and keep one hand at your side or in your pocket.



Remove blown fuse by turning counterclockwise. Be sure new one has same capacity

If fuse box has main disconnect of type above, pull it out to get all main fuses. This will

expose cartridge. Pull straight out; put in new fuse of same capacity type

Tripped circuit breaker. Easy to ... just push switch ... ease

Grounded wiring

Household wiring is color coded. In 110-volt circuits one wire is called the *neutral* wire; it is white. The other, the *hot* wire, is black or another color but never white. Both are live wires. In circuits carrying 220 volts only, one wire is usually black and the other another color, but neither should be white. In 3-wire circuits carrying both voltages one wire is white, the other two black or colored. You get 110 volts by connecting the white wire and a colored wire to an outlet, 220 volts by connecting the two colored wires to an outlet.

The fuse or circuit breaker panel of your home is **grounded**, that is, there is a wire connecting the service panel to a rod which is driven into the earth. In residential areas, this ground wire is usually attached to the water supply pipe which leads into the ground. The white neutral wires of the various branch circuits throughout the house are also connected to grounded terminals [illegible] necessary for a reduction of the possible effects of [illegible]

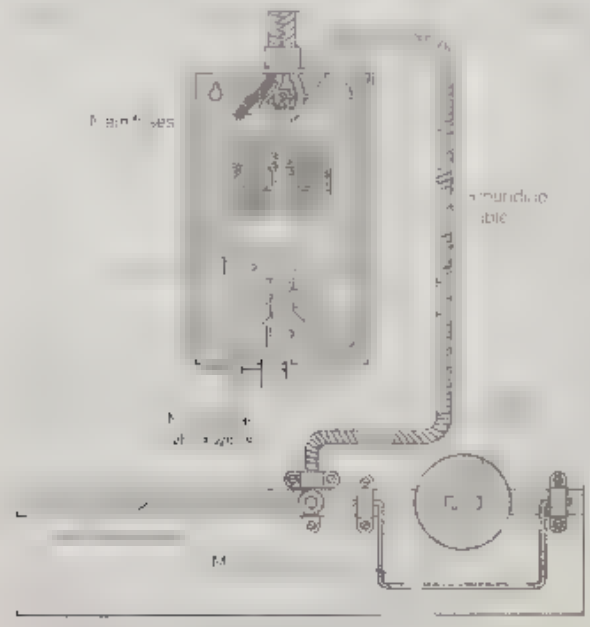
Grounded wiring systems are those in which all metal outlet and switch boxes, cable armor and exposed metal parts of the wiring system are connected back to grounding terminals in the fuse or circuit breaker. Grounding terminals of grounded receptacles are connected to the box by a jumper wire or other means. A 3-prong appliance cord continues the [illegible] such an appliance, such as a loose wire touching the frame, will immediately cause a fuse to blow or a circuit breaker to trip. Appliances or tools that do not have such protection can be dangerous—you could get a shock if something should go wrong with the internal wiring.

Check your system for grounding by seeing what type of wiring is installed in your home. If the wiring is of nonmetallic cable, that cable should have a third wire (which has no plastic sheathing) that is connected directly to the electrical outlet boxes. If your wiring is of BX cable, you know the system is [illegible] cable acts as a grounding conductor. Metal conduit also serves as a grounding conductor.

Once you have determined how your electrical wiring is grounded, you can carry grounding safety one step further by installing 3-prong electrical outlets throughout the house. Be sure that the third wire of the [illegible] (the bare one) is attached to the ground terminal on the outlet receptacle.

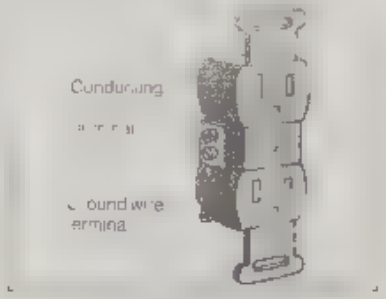
A less expensive [illegible] adapter plug. Be sure to connect [illegible] the plug to the screw on the electrical box plate. If you neglect to do this, the grounded circuit will be ineffective.

In double-insulated tools, all wiring is protected by an extra layer of insulation. With this extra layer, even if the primary insulation fails, no part of the tool can become electrically "live." The cover [illegible] that are equipped with 3-prong plugs however must be connected to grounded receptacles and used in conjunction with 3-wire extension cords.

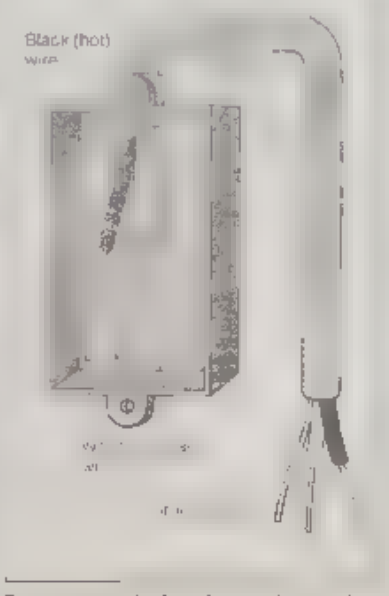


Electric service entrance is grounded to metal water-supply pipe or to a special metal rod driven into the earth.

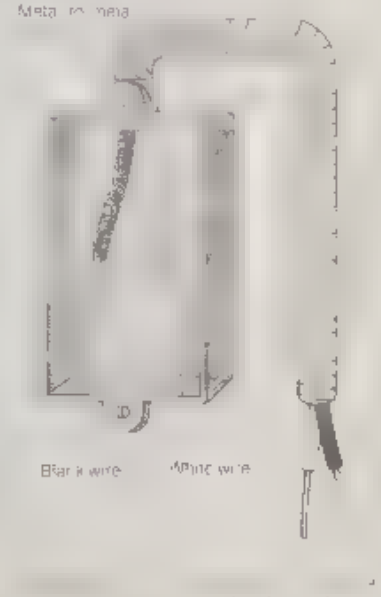
Fit 3-wire **adapter** plugs with pigtail attached to receptacle plate.



Three-hole receptacle has a green terminal screw for the grounding wire.



Copper ground wire of nonmetallic cable connects directly to outlet box.



Metallic sheathing of BX cable acts as ground conductor in older homes.

Tips to get you started

Inadequate power in the home does not mean that you must completely renew all wiring plus the service panel. Wiring can often be updated by the installation of additional circuits to your existing system. Completely renewed wiring should be left to the li[illegible] electrician, but by following the re[illegible] tions in this section, you can put more "horsepower" in your home's electrical [illegible]

[illegible]

electricians will be happy to inspect your work before making final connections for only a fraction of what they would charge for the entire job.

The code w[illegible] also determine what t[illegible]pe of wire you must use. Some ar[illegible]as use Romex (a fabric-covered wire), others recommend BX (armored [illegible]able). Wire size is important. Wires are rated by numbers, the lowest numbers [illegible]ndicating larger diameter wire.

Number 12 wire is generally recommended throughout the home. Number 14 wire can be used, however, for 15-ampere circuits.

Part of your planning includes checking the exist[illegible]

ut[illegible]ity company to be certain that the lines leading into your home have the capacity to deliver the extra power the new circuits would require.

Refer to the electrical service panel illustrated here for help in determining what circuits should [illegible]

[illegible] A kitchen [illegible] every 4 fe[illegible]

[illegible] except for the kitchen [illegible] should be planned on the basis of [illegible] ampere 120-volt [illegible] for every 500 square feet of floor space or one 15-ampere 120-volt circuit for every 375 square feet of floor space. Outlets should be spaced every 12 feet around the walls of each room.

Efficient light and appliance circuits

General-purpose circuits of 15 and 20 amperes take care of a[illegible] amps [illegible]

[illegible]

Service [illegible] such as a [illegible] shop should be on a separa[illegible]

[illegible] are generally sufficient

Improving electrical service

Relieving overloaded circuits

Overloaded circuits are caused by the use of too many appliances at the same time. For example, if the kitchen electrical outlets share the same circuit with the lights, a refrigerator, a radio, or some other appliance, the chances are that your fuses blow whenever all of these are operating simultaneously and you switch on a fry pan or toaster.

You can eliminate this kind of overloading by connecting a 4-outlet appliance plug box directly to the electrical service panel. Top sketch shows a 120-volt split circuit connecting appliance outlets to two spare [illegible] entrance panel. This hook-up allows you to use four appliances [illegible] at up to a 4500-watt capacity.

Before planning this installation, see if your fuse box has two unused power takeoffs. These can be recognized by two empty spaces that would accept a fuse [illegible] If [illegible] an [illegible] electrical panel.

Once two power takeoff terminals are established [illegible] to the service panel.

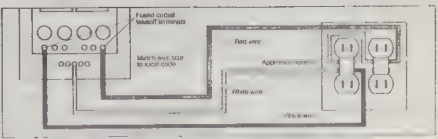
Installing an 'add-on' panel. These units do the job of a small electrical service panel. The power from the main service entrance flows into the add-on panel and is distributed to the supplementary circuits.

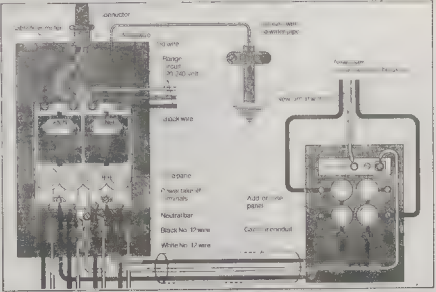
[illegible] the [illegible] right plug fuses. Wires [illegible] panel are [illegible] The two black wires go to the terminals and the white wire goes to the neutral bar.

At the add-on panel, both black wires are joined to the fuses' screw terminals and the white to the neutral bar. New circuits are then connected.

How to avoid danger

Working with electricity is not hazardous as long as you obey [illegible] safety [illegible] Always shut off or disconnect power [illegible] handling wires. If you are working on the electrical service [illegible] do not stand on a damp floor. Protect yourself by wearing rubber gloves and rubbers and stand on a rubber mat or [illegible] Above all, if you are in any doubt about how to do any particular job, call in a licensed electrician.





Three-wire electrical cable in older homes will have two black wires and one white one. In more recent construction this has changed to one black, one red, and one white. Present electrical codes call for a fourth wire, which is a ground. This ground wire is bare metal. To avoid confusion, ground wires have been left out of these illustrations.

Electrical repair guide

Aids to easy repair

If you can follow the operating instructions for a dishwasher dryer or modern electric range, you can learn the necessary technical facts and techniques to handle dozens of minor electrical repairs. Replacing an old wall switch with a new silent type, installing a dimmer switch, replacing broken lamp switches, hanging a new ceiling fixture—these are typical tasks that can be easily accomplished with a minimum of skills and tools.

Even the seemingly more complex jobs, such as installing an additional electrical outlet or wiring a new circuit, are a simple matter of following the step-by-step instructions in this section.

Important: Unplug appliances you are working on. If changing switches or electrical wiring, remove the **fuses or shut off the circuit breakers that supply power to the circuits you are working on.**

You probably already have most of the tools that are required for minor electrical repairs or wiring. These include screwdrivers, knife, ruler, hammer, [illegible], electrician's pliers, metal [illegible].

[illegible] Phillips-type screwdrivers for [illegible] slotted screws often used in appliances; nut drivers that have a socket on their end to drive or remove nuts in areas in which a wrench would not fit.

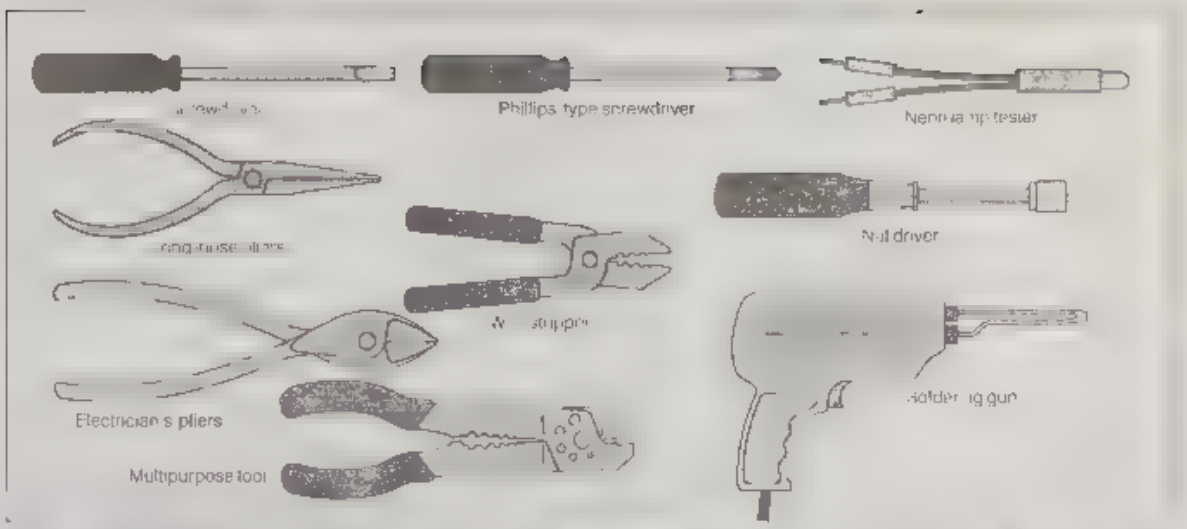
Another necessity is a **neon lamp tester**, a small light with two wires that are inserted into an electrical outlet to see whether power is present.

Long-nose pliers are used to hold screws, nuts, and similar small hardware so that you can insert or remove them in hard-to-reach places inside walls or appliances. They are equipped with side cutters which can be used for cutting wires.

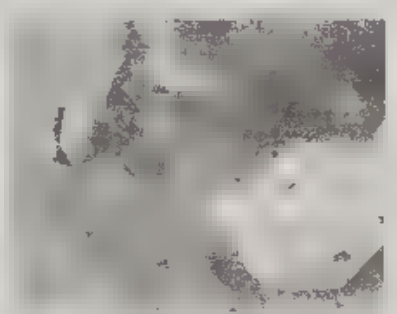
Wire strippers slice neatly through the insulation covering a wire and remove it without disturbing the wire itself. This is a necessary step prior to making connections with new wire. There is also a **multipurpose tool** that cuts and strips wire and can crimp terminals (fasteners) to the ends of a wire, joining them without the use of solder.

In electrical work a **soldering gun** is a better choice than a soldering iron because it heats faster and has an easily held pistol grip.

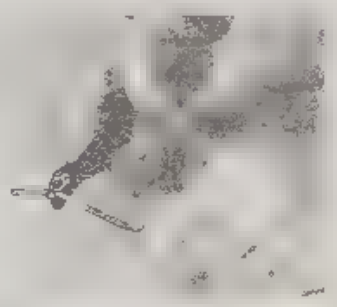
Tools and their uses



Side cutters of electrician's pliers cut through wire. Can be used as strippers.



Crimping of solderless terminals joins wires without the use of solder.



Stripper [illegible]

Test lamp inserted in outlet lights up, signaling presence of electricity.

Soldering gun melts solder to form permanent electrical connections.

Nut driver reaches nuts in cramped areas where wrenches do not fit.

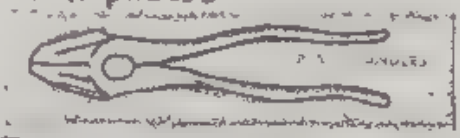
The most common type of electrical current supplied by the utility companies is alternating current or A.C. The reason for this is because alternating current can be transmitted over long distances with a minimum of loss, thus giving more efficiency to the system.

One must remember that whenever or wherever electricity is concerned we always have an electrical code that must be adhered too. If we follow the code exactly, then there will never be any mistakes or accidents. Some areas require that only a licensed electrician be able to do these repairs or installations. So check on this before you start anything pertaining to electricity.

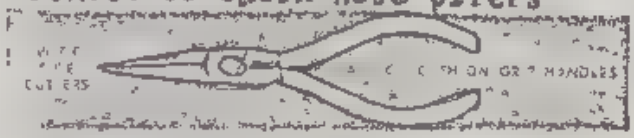
Tools and Materials

If you are the average fix it or handyman, chances are you already have the basic tools, but if you aren't the following is a list of essentials that you may need:

(1) Line man pliers



(2) Needlenose or chain nose pliers



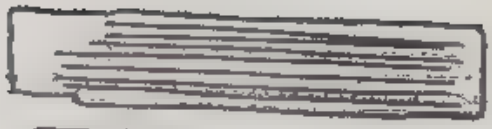
(3) Diagonal cutting pliers

(4) Assorted screw drivers

(5) Pocket knife

(6) Hack saw

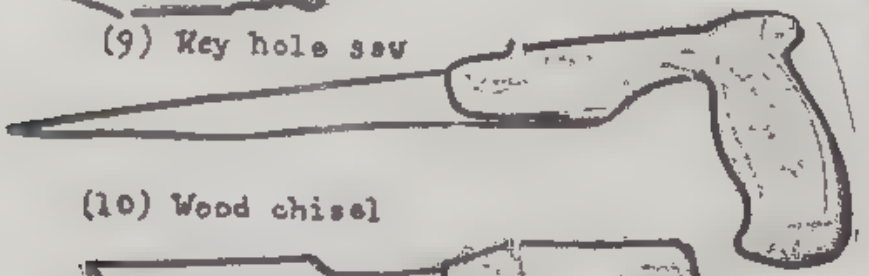
(7) Rulers



(8) Brace

Wood bits

(9) Key hole saw



(10) Wood chisel

(11) Tin snips

(12) ball peen hammer

(13) Claw hammer

(14) Flash light

(15) tester

(16) Tape - plastic, friction and rubber

Electrical boxes and accessories

Wall boxes

1 Metal box is flush mounted in lath wall. Surface mounted is also available

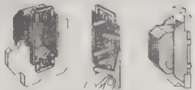
2 Several metal boxes are joined together by removing the side plates

3. Metal box with a flange is nailed to the front or rear of stud in drywall

4. The flange on this box can be screwed to the side of stud in drywall

5. Small side flanges of this box can be nailed to side of stud in drywall

Wall box accessories



Mount wall boxes between studs in drywall with box clamps, left, which grip rear side of wall as side screws are tightened. Or use metal supports, right, that slip in hole; projecting tabs are bent into box

Boxes for damp locations

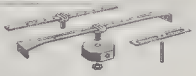
Weatherproof outlets, switches, and boxes for outdoor installation. Single or multiple outlets have snap covers. Both single and three way switches are available

Bakelite wall or ceiling boxes used in damp areas cannot be ganged together

Ceiling boxes and accessories

Metal boxes for ceiling mounting are made square, octagonal, and round

Flange on this metal box permits it to be nailed or screwed to joists in a ceiling



Adjustable hangers, left, permit ceiling boxes to be fastened between ceiling beams. Shallow box hangers, right, rest on ceiling laths

Thin-walled conduit and accessories

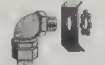
Fiber ring inside nut clamps conduit pushed into it. Tightening coupling joint secures both pieces

Fiber ring inside this nut clamps conduit and coupling joint. Coupling joint is secured to box with locknut

A 50-ft. fish tape (p. 264) attached to the wire is used to pull the wire through a conduit or through a wall

Adapter on end of unthreaded conduit attaches conduit to threaded box

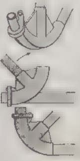
Various types of metal clamps and screws attach the conduit to a wall.



Fiber ring inside nut attaches conduit to right-angle adapter. Adapter is held to the box with a locknut

Rigid threaded conduit inserted into neck of threaded box is securely attached to the box with metal clamps.

Bending conduit with a hickey



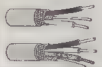
Make bends in conduit with [illegible] must not exceed 36[illegible]

Hook bender over conduit with the inside of the grip hook at mark. Bend the conduit by pulling the handle back in the direction of the bend

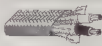
Placing a foot on a straight section of conduit makes bending easier. Check the bend often as you go to be sure that the angle is correct

Types and uses

Nonmeta[illegible]c and metallic cable



Buying cable: Cable is classified according to the [illegible] wires [illegible] and their size [illegible] gauge. Two-wire cable [illegible] con[illegible] wires [illegible] the black [illegible] the white [illegible] wire and a third which is the ground wire. Similarly, 3-wire cable [illegible] wires: Black, white and red (which is also a hot wire) and a ground wire.



Service entrance cable: Used to transmit power [illegible] switch. Can be used indoors or [illegible]. Also used [illegible] large appliances [illegible] ranges and water heaters. Usually a 3-wire [illegible].

Nonmetallic sheathed cable: For indoor [illegible]. Has a [illegible] resistant, flame resistant [illegible] made with and without a [illegible] wire. The wires are copper or aluminum. No. 6 and larger are stranded.

Underground feeder and branch circuit cable: Can be used underground, indoors or [illegible] require a conduit when buried. Resists water and corrosion.

Extension and appliance cords: Come in [illegible] types. Lamps usually use plastic [illegible]. Appliances and motors take heav[illegible] with wire size to [illegible]. Extension cords are sold with connectors at each end.

Armored and special-purpose cable

Armored BX cable: Used only in dry indoor locations. [illegible] bare ground may be [illegible]. Must be used with steel junction and switch boxes. Made in 2- and 3-wire types.

Ground wire: Used to ground an electrical system [illegible] water [illegible] or to a copper rod [illegible] in the ground. Generally single-wire armored cable. Wire size depends on service wire size. Check local code.

Lead-encased underground cable: Generally used to transmit power to outbuildings from main power source. Must be substituted for plastic-covered wire if local electrical [illegible] requires [illegible].

Thin-wall steel conduit: Required by some towns. Installed same way as piping; wires are pulled through afterward. Acts as its own grounding conductor. Made in 10-ft lengths joined by special connectors.

Wire sizes

Wire sizes for residential wiring vary from No. 14, the smallest permitted, to No. 0. (Sizes [illegible] 0000 available for special work.) The smaller the number, the larger the size. The wires shown are actual sizes. No. 6 and larger wires are stranded.

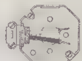
Installing nonmetallic cable

1. Strip off about 6 in. of the cable covering. Be careful not to cut insulation.

2. Remove the outer wrapping from each of the wires' insulation [illegible] inside wrapping.

3. The next step is to strip off insulation to expose about 1 in. of the solid copper wire.

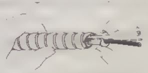
4. Install the connector. Use the kind made for nonmetallic cable with two locking bolts.



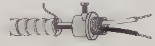
5. Tighten the bolts so connector is secured to cable. Insert into box. Install locknut.

Installing BX cable

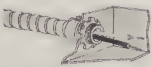
1. Use a hacksaw to cut off about 6 in. of the armor. Be careful not to cut into the wires.



2. Remove 1 in. of insulation from each of the two wires. Insert insulating fiber bushing.



3. Install special BX cable connector. Make sure cable fits snugly in it; tighten screw.



4. Push cable into junction or switch box and install locknut. Allow 6 in. for connection.

Switches, Replacing

When wall switches fail to operate properly, or when a dangerous arcing, or sparking, condition is noticed, the homeowner can replace the switches quite easily, using modern types which can be installed in the original wall box in place of the old switch. In addition to simply turning the lights on and off, these new switches offer many refinements and conveniences.

Among the many variations available are switches which turn lights on and off noiselessly, switches which glow in the dark, switches which can be set to go off or on at predetermined intervals, switches which have rotary knobs instead of toggles and switches which can be operated by lightly tapping with an elbow when the hands are full. In addition there are special dimmer switches which can be used to control the brightness of the lights as well as to turn them on and off.

To install most of these switches, no rewiring or other alterations are required. The steps involved are simple. First - and most important of all - turn off the power by pulling the main switch or by unscrewing the appropriate branch fuse. Then unscrew the cover plate and remove the two screws (one at the top and one at the bottom) which hold

the switch in place against the front of the outlet box.

Pull the switch out of its recess and unhook the wires connected to it by loosening the terminal screws to which they are attached. Then hook these wires up to the terminals on the new switch, being careful to connect the black wire to the dark (brass-colored) terminal and the white wire to the light (silver-colored) terminal. Fold the wires back into the box and press the new switch into position against the front of the box. Tighten the screws which hold it in place, then screw the cover plate back in place to cover the opening. With most switches the same cover plate can be used, but with some, special matching plates will be supplied.

Switches which are silent in operation are probably the most popular of all. These are mercury switches, which resemble conventional toggle switches in appearance, and they are widely available [illegible] stores and electrical supply houses.

Noiseless switches that feature a tap action, rather than a toggle action, are also available. These have a large single button that turns the lights on or off each time it is tapped. This means the button can be tapped with an elbow - or with almost any other part of the body - when hands are full. Screwless, spring-action terminals make it possible to connect many of these switches simply by pushing the bared wires into

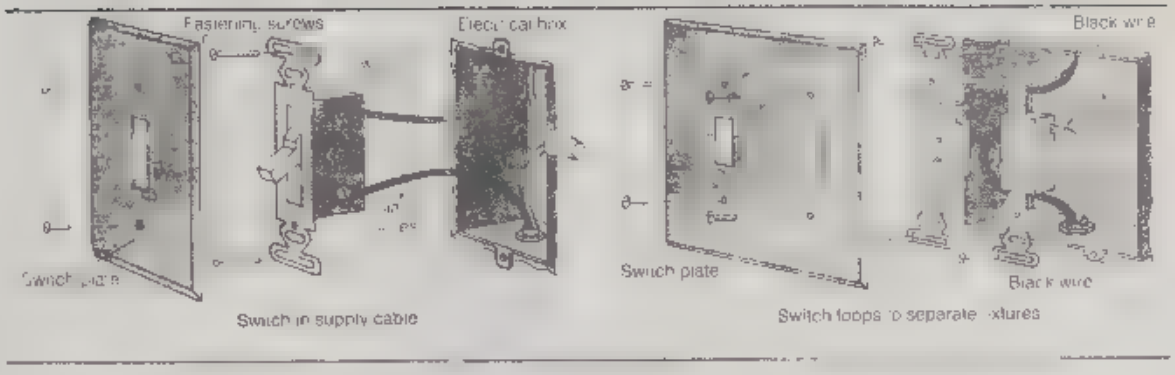
the openings in the back of the switch case. They are instantly locked firmly and permanently in position without any chance of working loose.

Switches and outlets

Replacing a switch

Switches are always in the hot (black wire) side of the circuit, never in the neutral (white wire) side. So they connect to black wires only, except in switch loops or multiwire switching.

To remove old switches, you must first remove the fuse (or turn off the circuit breaker) that controls the switch. Then remove the switch plate and the screws holding the switch in the switch box. Tug the switch out of the box so that the wires are accessible. Release the wires from their respective terminals and replace them in the same position on the new switch. Fasten connections and tuck the wires and the switch back into the box. Fasten the screws and replace the switch plate.



Replacing an outlet

If an electrical outlet is faulty, it will short circuit and blow a fuse (or trip a circuit breaker) whenever an appliance or lamp is plugged into it. To test whether the outlet or the appliance is faulty, plug in a lamp you know is working. If the lamp does not light and the circuit breaker trips or the fuse blows, the outlet is faulty.

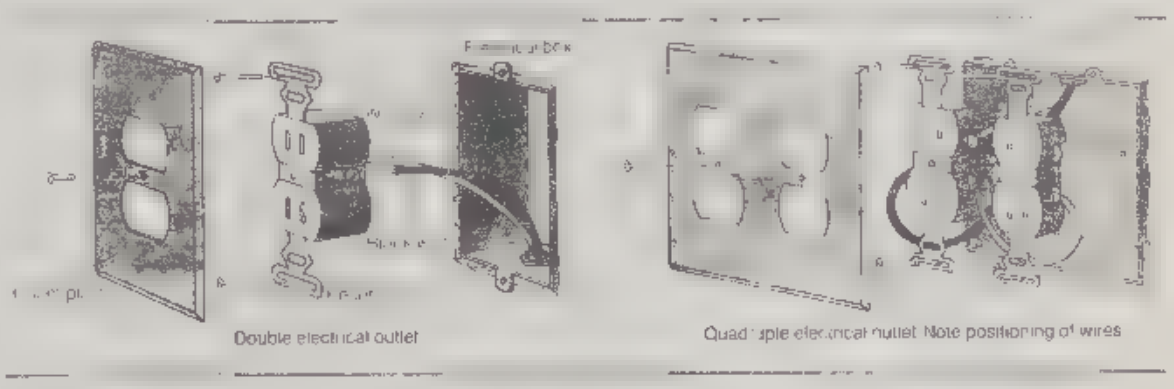
To remove a damaged outlet, turn off the power to the affected circuit. Remove the outlet plate, remove the two screws holding the receptacle and pull the unit out of the box. Remove the wires from their respective terminals. Connect the same arrangement on the new receptacle. Many new receptacles are the 3-wire grounded type, in which case you can either ignore the ground terminal or run a short length of wire from the ground terminal directly to the outlet box, following local code.

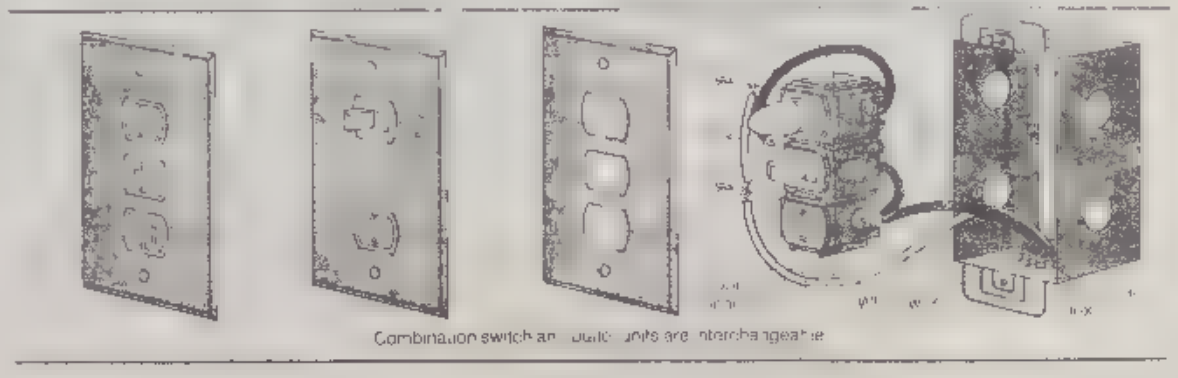
Multiple switches and outlets: Usually you would only have to replace one switch or outlet from a multiple unit. These units can be tested in the same way as the single units.

Position of terminals of multiple switches and outlets may vary slightly on some brands. The important thing is to place all the wires removed from the old switch or outlet on the same screw terminals of the new unit.

Combination units. Combination switch receptacle units are wired similarly to the single and double switches and outlets. Each switch, outlet, or pilot light requires one common wire obtained by using jumpers to connect all three terminals.

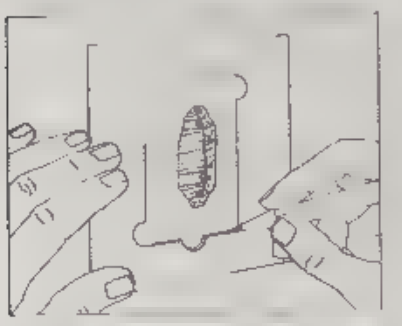
Grounding wires not shown on this page.



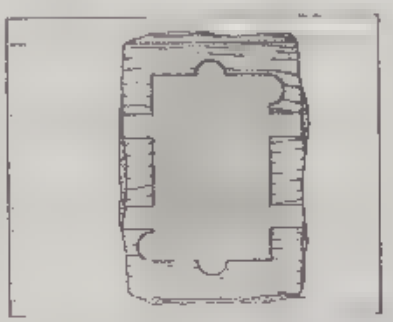


Lath and plaster walls

Ideal positioning for switch boxes is about 4 feet from the floor; for outlet boxes, roughly 12 to 18 inches off the floor. Outlets for wall-mounted light fixtures should be 60 to 70 inches above the floor. Be sure to mount switches on the opening side of a door rather than on the hinged side. Always use 2½-inch-deep electrical boxes rather than the shallow ones, unless some structural problem will not permit the deeper box. With lath and plaster construction, you can locate an electrical box almost anywhere along the wall, since the wooden lathwork is strong enough to hold the box securely.



Locate stud. [illegible] Saw hole large enough to expose laths. Use template at right to outline hole to be made in the wall.

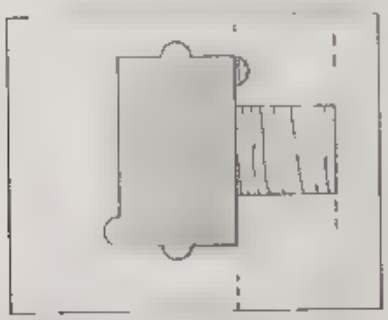


Remove plaster. Drill saw holes. Hold your hand against wall to prevent cracks. Cut away center lath completely. Cut sections from laths above and below.

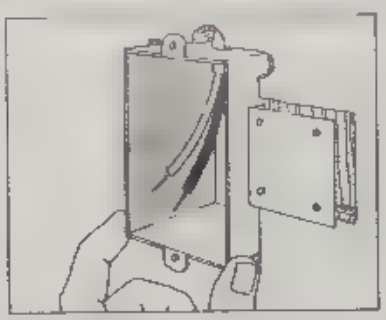
Punch knockout disks from box. Pull wires through hole. Attach connector. Install locknut. Push box into hole. Anchor box to lath with wood screws.

Drywall installations

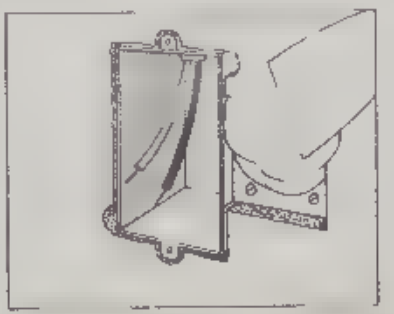
In drywall or wood paneling, boxes can be mounted between studs by means of special clamping devices (p. 260) that grip the inside of the hollow wall. The strongest point in this type of construction, however, is at the studs. You can get boxes equipped with brackets that can be nailed or screwed directly to the face of the studwork. To fit boxes directly onto the studs, you must first locate the stud, then chip a notch out of the drywall large enough to accept the fastening bracket. Connect the wires to the box before placing it in the hole. When installation is complete, patch the hole.



Locate stud. Notch drywall to expose stud. Outline area next to stud with template and saw holes. Hold hand against wall to prevent cracks. Saw out section.



Punch knockout disks from box. Pull wires through hole. Attach connectors. Install locknut. Line up bracket with stud and push box into hole.



Anchor box bracket to stud with screws. Fill area around box and bracket with either plaster or spackle so that it is flush with the wall surface.

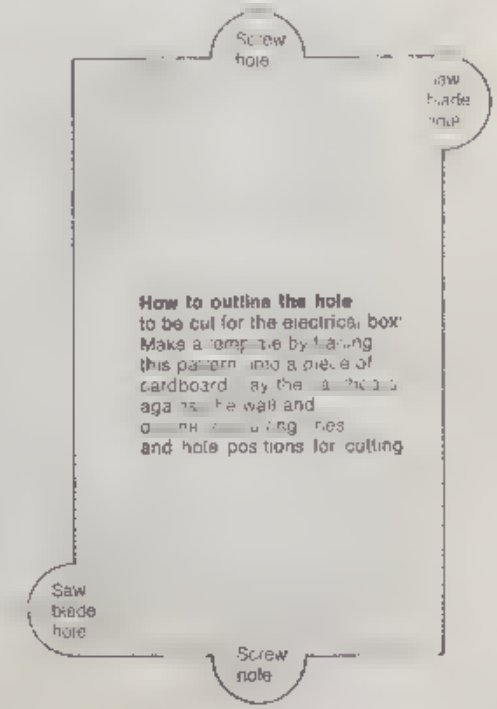
Locating studs

There are several methods for locating studs. One of the following should work for you.

1. Tap the wall lightly at points above the nails in the baseboard. A hollow sound means there is no stud. A solid sound indicates the presence of a stud. To be sure that you have found the stud, use a small drill (⅛ inch) to bore holes in the wall slightly above the baseboard. Drill several holes side by side until you bore into the stud.

2. Baseboard removal. With the baseboard [illegible] check to see [illegible] panels of drywall meet. This point will indicate the center of a stud. This method also works with paneled walls.

3. Measuring from the corner. Studs are generally located either 16 or 24 inches apart. Which [illegible] depends on local building codes. Try measuring out from the corner of a room to find the approximate location of a stud, then use the drill technique described above to [illegible] stud location.



How to outline the hole to be cut for the electrical box: Make a template by tracing this pattern into a piece of cardboard. Lay the [illegible] against the wall and [illegible] and hole positions for cutting.

Electrical box template

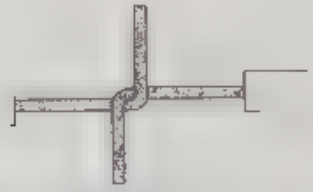
Wiring switches, outlets, and fixtures

Wiring 2-, 3-, and 4-way switches

How a switch outlet or fixture is wired depends upon its location in relation to the wires that lead from the main service entrance. The diagrams on the following three pages show a variety of common switch outlet, and fixture wiring installations. To use these, find the diagram that most closely resembles your wiring arrangement. Then follow the pattern of joining white wires to white wires and black to black.

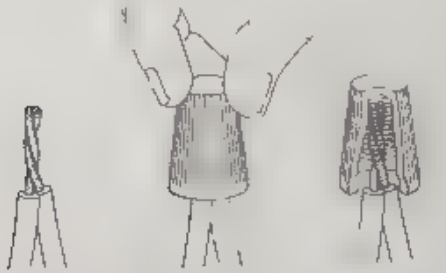
The white wires are always neutral; the black ones always hot, however in certain switch installations both black and white wires are hot. In such cases you should dab black paint on the white wires at the switch and fixture to indicate a hot wire. **Drawings are diagrammatic, without grounding wires.**

Two-wire joining methods

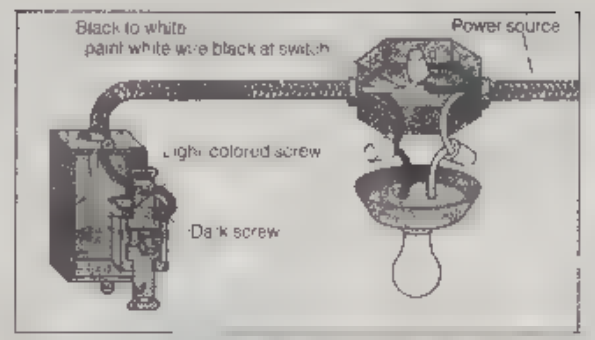


1. Remove 3 in. of insulation from each wire. Cross and twist wires together 1 in. from the insulation.

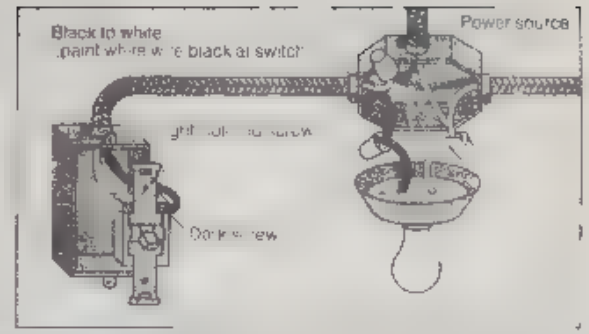
Make six to eight turns in twisted wires with fingers and pliers. Solder wires together. Tape after soldering.



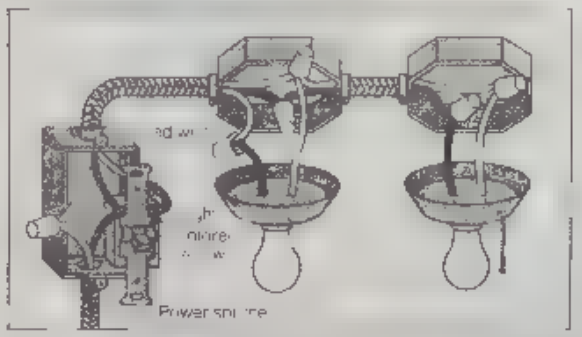
2. Twist ends of wires together as shown. Screw wire nuts on ends to form connections without use of solder.



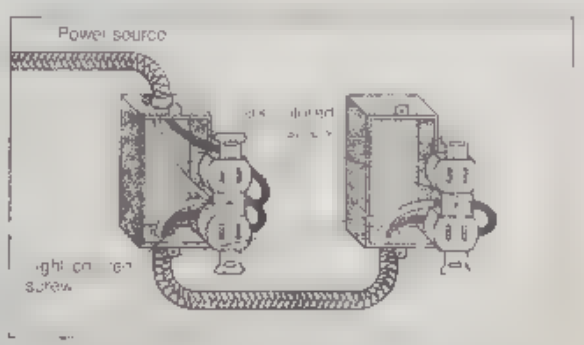
Wall switch to control ceiling fixture at the end of its run. Note that black feed wire is connected to white wire from the switch. Paint white wires at fixture and switch black.



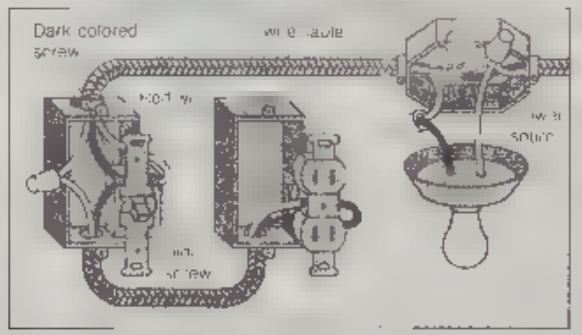
Wall switch to control ceiling fixture in the middle of run. This wiring hookup is similar to wiring at left. Paint white wires at switch and fixture black to indicate they are hot.



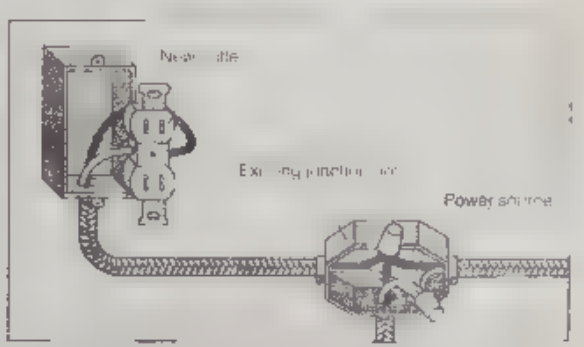
Two fixtures on the same line controlled by different switches. Fixture on left is controlled by switch to the left. Fixture on right is controlled by pull chain on fixture.



Adding a supplementary outlet to an existing outlet. Feed wire to top terminals on existing outlet (left). New outlet is connected to lower terminals.

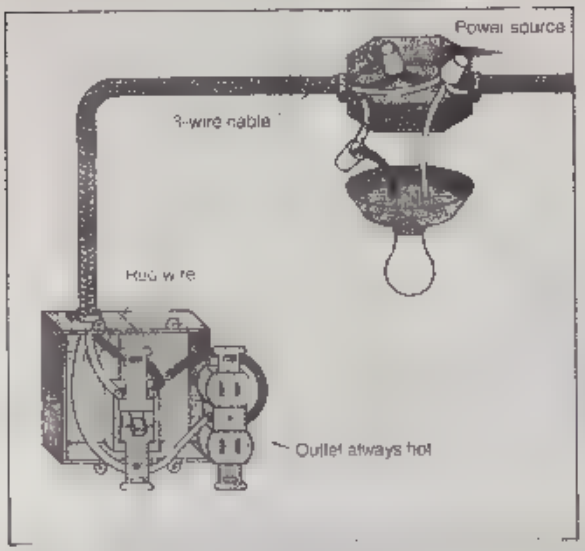


Adding a new switch and outlet to an existing ceiling fixture. Fixture is controlled by wall switch. Operation of new outlet is unaffected by operation of wall switch.

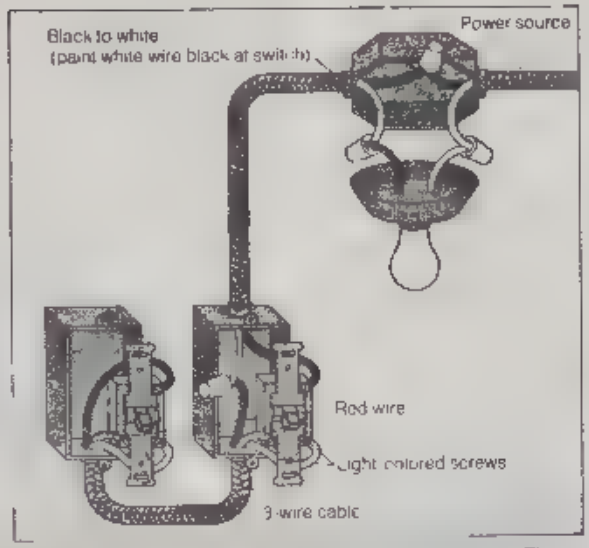


Adding a new outlet or fixture to an existing junction box. Same wiring arrangement as for outlet could be used to connect a new ceiling fixture instead of an outlet.

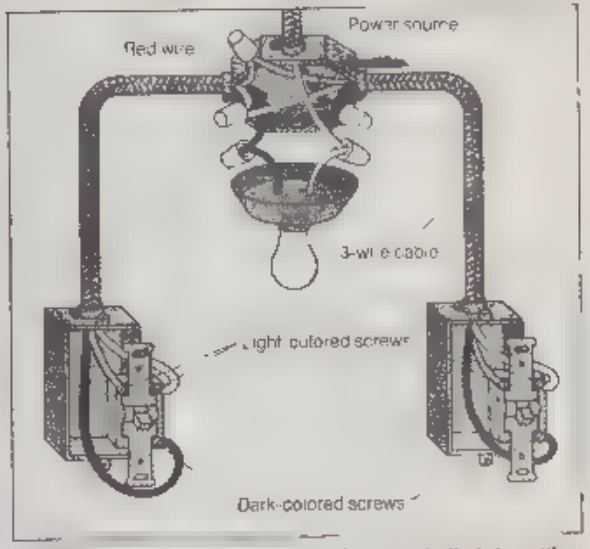
Wiring 2-, 3-, and 4-way switches



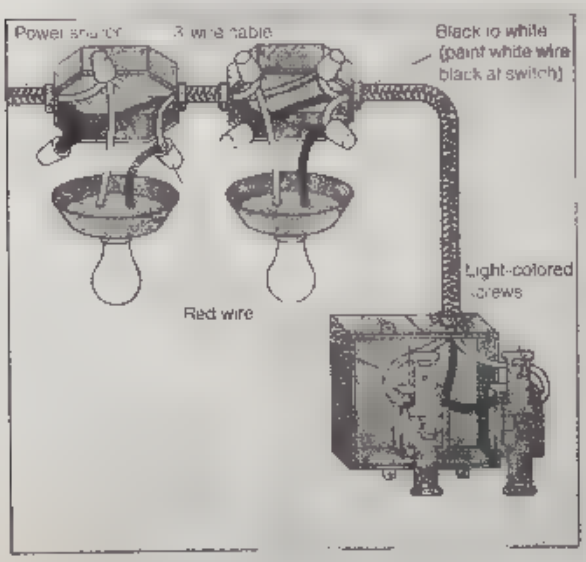
Adding switch and outlet in the same box to ceiling fixture: Existing ceiling fixture is controlled by new switch. Operation of new outlet is unaffected by new switch.



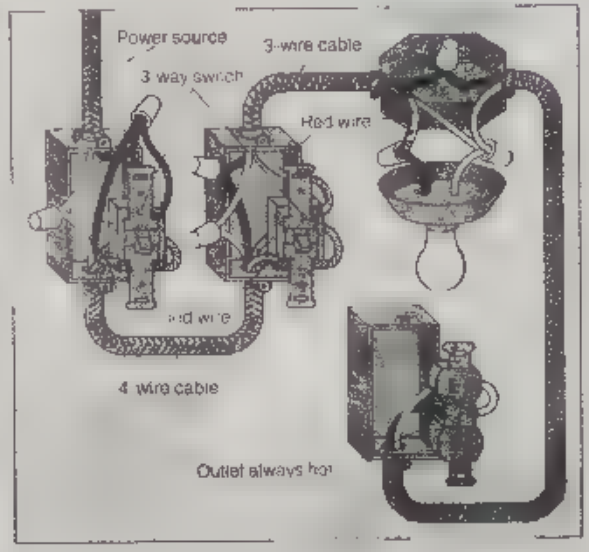
Same ceiling fixture controlled by [redacted] different switches: Three-wire cable must be used between switches. Either switch, each located at a different spot, can control fixture.



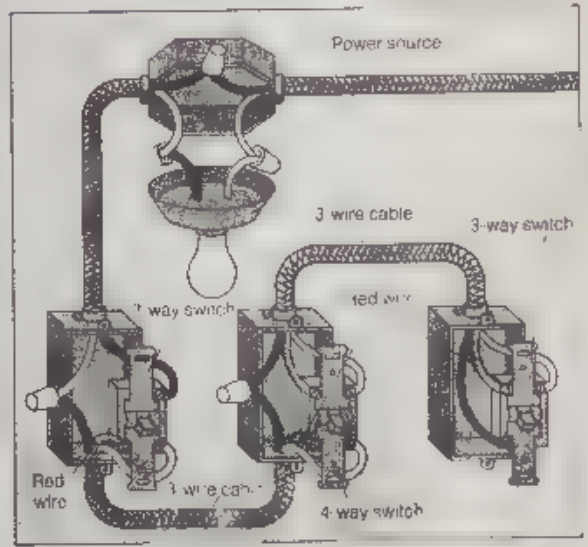
Ceiling fixture between two switches, controlled by either: Three-wire cable connects each switch to the fixture. Feed wire to fixture is a 2-wire cable.



Two separate fixtures controlled by two switches: Left fixture controlled by left switch. Feed wire is 2-wire cable. Fixture and switch connections are 3-wire.



Fixture controlled by separate switches, outlet always hot: Feed wire and outlet connections are 2-wire cable; connections between switches and outlet, 4-wire cable or two 2-wire cables.



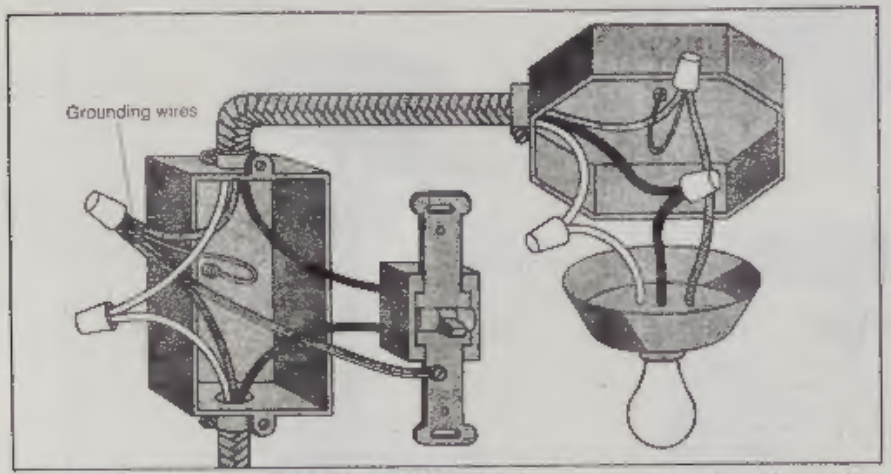
Ceiling fixture controlled from three separate locations: Two 3-way switches and one 4-way switch are required. Each extra control point requires an additional 4-way switch.

Wiring code

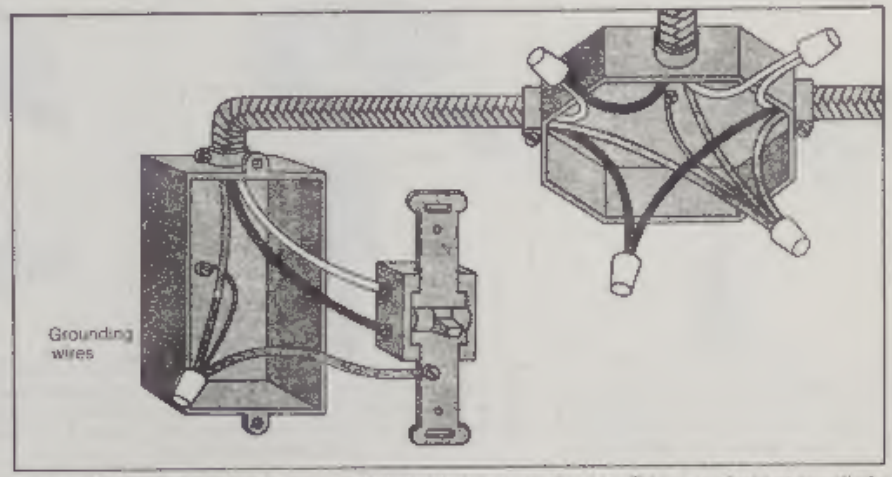
New grounding requirements

You should be aware of a change in the National Electrical Code: An improved grounding system that offers far greater safety than the conventional method of grounding by means of the metal in BX cable or conduit. Basically it consists of an extra wire that now becomes part of the grounding system, with this important step: Grounding wire, instead of being connected to the grounding post of an outlet, is connected to the metal box that houses the outlet. Then a jumper wire is connected from the box to the outlet. The reason for the jumper wire—instead of the wire being directly connected to the receptacle—is to assure a continuous ground. With direct connection, if the outlet were to be removed and the wires taped up, grounding wire would terminate in the air, so to speak, and break the ground. With the wire connected to the box, the grounding system is continuous even if the receptacle is removed from the power source and from the jumper wire.

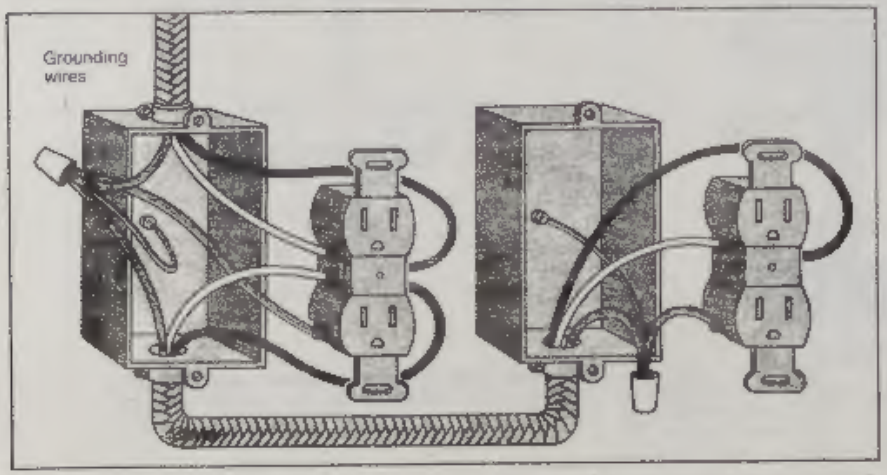
Not all switches have grounding terminals, which are often used with nonmetallic boxes.



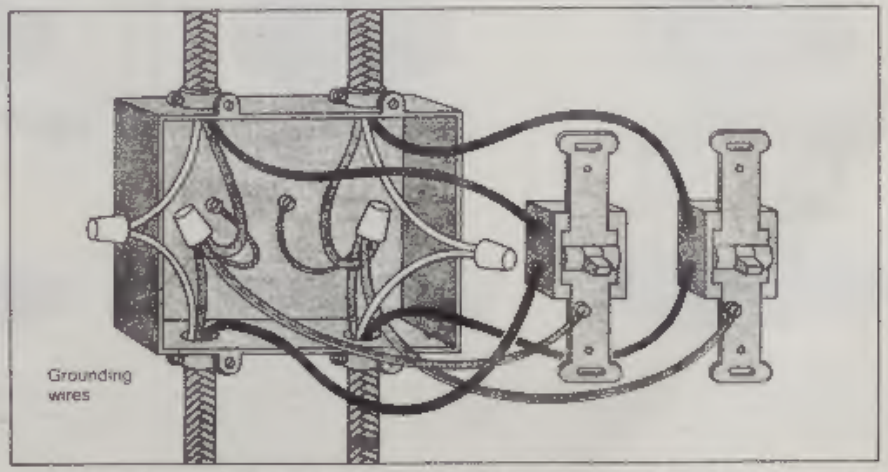
Wiring hookup for a light controlled by a switch, using the new grounding system. All new wiring must have an extra wire as a ground; with Romex, use the bare middle wire.



Switch wired through junction box controls light at far end of cable. This type of wiring is called a switch loop. White wire leads to switch; black wire leads from switch to fixture.



Extending power to a new outlet. Both outlets have a self-grounding strap and binding post that is connected by means of the jumper wire to the grounding post in each box.



Two switches independently controlling two ceiling fixtures and wired according to the revised code. Grounding terminal is lacking on many switches but must be used if required by local code.

How to install a chandelier

Use a sturdy ladder to work on ceiling fixtures. Check whether you can do the job or if it must be done by a licensed electrician (or approved by one).

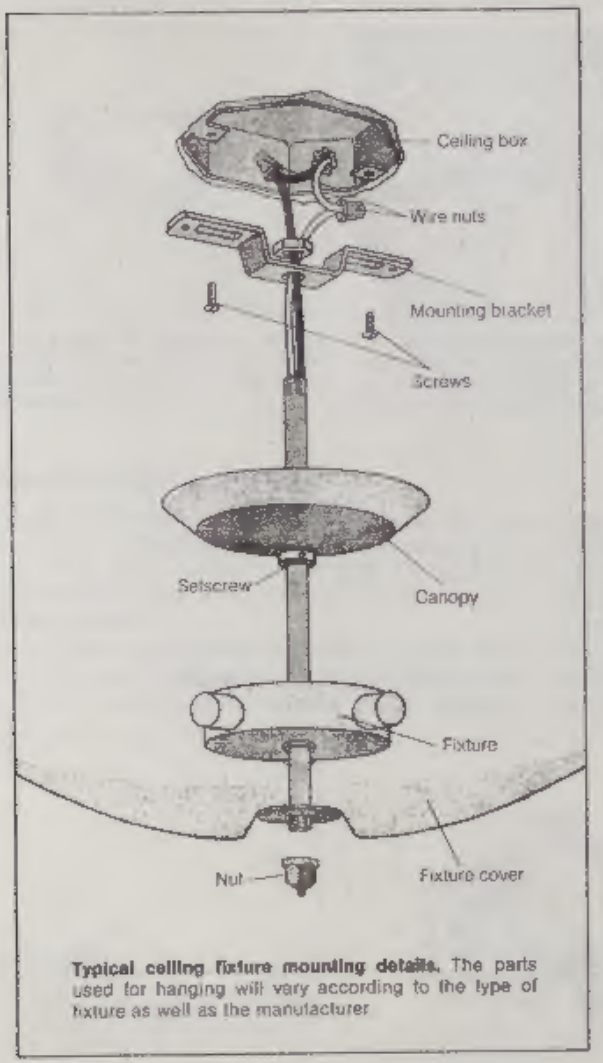
Before beginning any work, turn off the main power source or the circuit controlling the light.

Use a test light to find out if the wiring is still "hot."

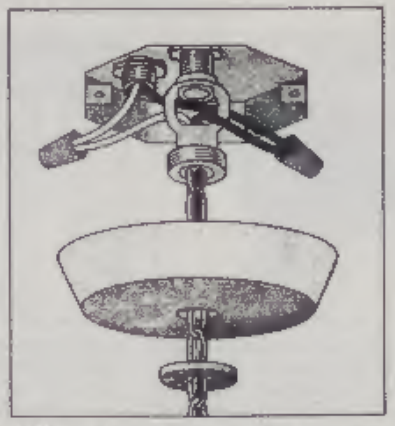
If the old fixture hanger or bracket is the same as the one that comes with the new fixture, use the old one.

You will need to support the fixture as you work. You can do this by bending a coat hanger to size and hooking it to the new fixture and ceiling box, or you can tie the fixture to the box with strong cord.

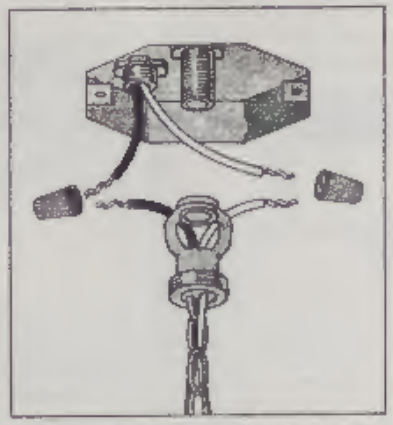
Connect the black wire in the ceiling box to the black wire of the fixture, and the white wire to the white wire. Make sure the wiring doesn't rub against any surface that might wear through the insulation. Apply tape to any such possible areas. If you use wiring nuts, tape them so that they won't loosen. If you prefer soldered connections, tin wires first, solder them together, then apply enough tape to equal the thickness of the scraped-away insulation.



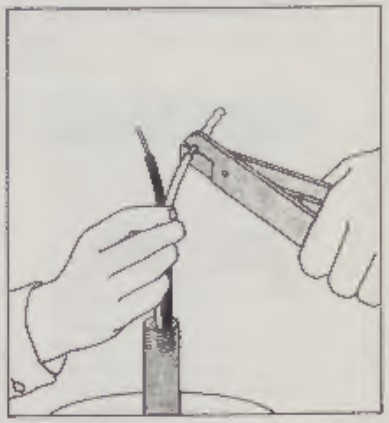
Typical ceiling fixture mounting details. The parts used for hanging will vary according to the type of fixture as well as the manufacturer.



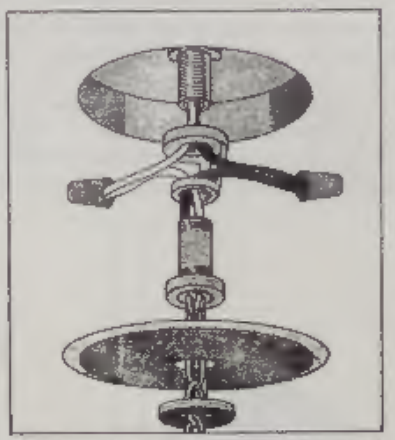
1. Turn off power. Loosen and remove the chains. Holding canopy in one hand, loosen setscrew or locknut at bottom of canopy. Lower canopy.



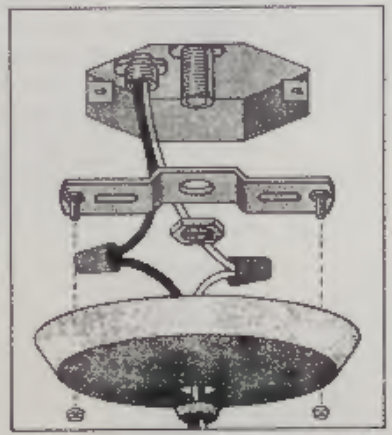
2. Support the fixture; pull out wires. Remove nuts holding wires together or cut the connections. Unscrew the nipple from the stud in ceiling box.



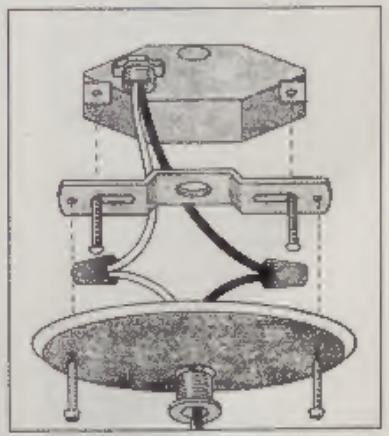
3. Strip a 2-in. length of insulation from the wires of the new fixture. Use wire nuts to make connections between fixture wires and the wires from ceiling box.



4. Screw nipple back to ceiling box stud. Connect fixture and ceiling wires, black to black, white to white. Push up canopy and secure with locknut or setscrew.



You may encounter this type of installation, where a steel bracket is connected to a stud in the center of the box and fixture is bolted to the bracket.

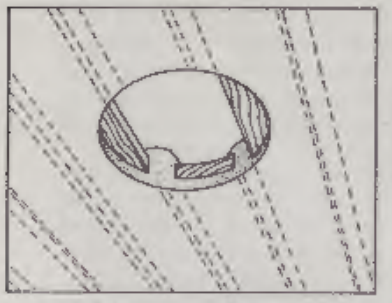


Another possibility: The bracket is bolted to the ears on the sides of the box, and the fixture is also bolted to the bracket as shown in drawing above.

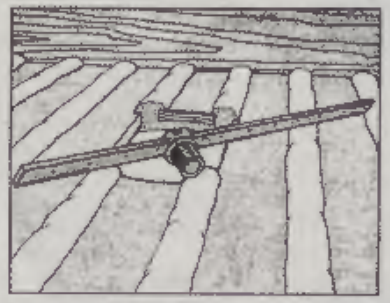
Floor and ceiling wiring

Mounting a ceiling box

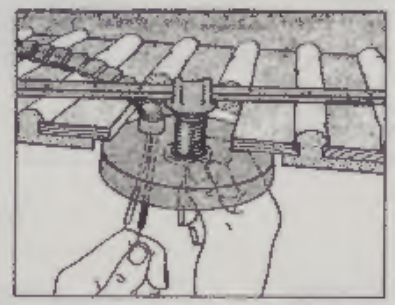
If you plan to install a ceiling light and the space above the ceiling is not accessible, you will have to work from below. Cut away plaster or other ceiling material to fit a shallow box, then any backing that is in the way. Fish the BX cable through the opening. Next install a hanger bar across the opening. Thread the cable through one of the holes in the box; secure with a locknut. The stud on the hanger passes through the center hole of the box. Tighten the nut until box is secure against backing. A shallow box is recommended; few chandelier canopies are large enough to cover a full-size box.



Draw box outline on ceiling and remove plaster or other ceiling material up to backing. Carefully cut away any backing that is visible through the hole.



Fish the BX cable through the hole. Insert hanger bar so it will rest across the backing material. Stud on hanger bar should be long enough to pass through box.



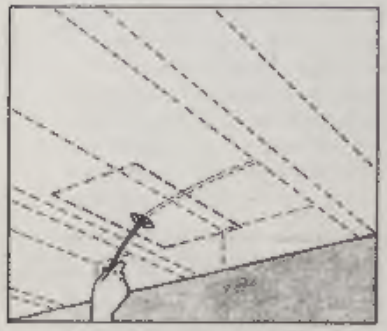
Pass the cable through one of the holes in the box and secure it with a locknut. Raise the box so that stud will pass through the center hole; secure with nut.

Recessed ceiling fixture

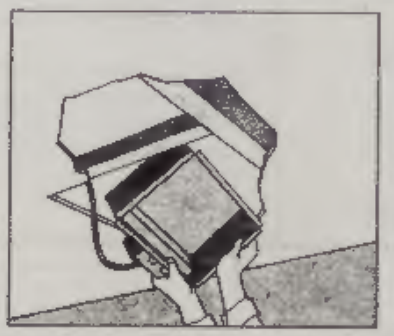
To install a recessed ceiling fixture, first locate the ceiling joists, by touch and sound or, if necessary, by drilling a few holes with a small drill. Outline the space between the joists for the box. (Joists are usually 16 inches apart.)

Saw out the required section with a keyhole saw. Next screw wood strips between joists to support the box. Some manufacturers supply metal support strips as well as junction boxes as part of the fixture.

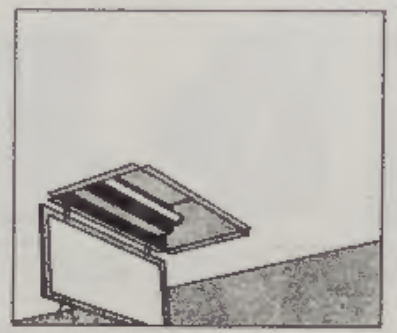
Bring the cable to the junction box and secure it with a locknut. Allow 4 inches of wire beyond the locknut for connecting. Make sure that the cable end is protected with an insulating sleeve. Connect the white wire to the nickel-plated binding post and the black wire to the brass-plated post. Push the fixture into the opening; secure it with roundhead screws.



Locate joists by tapping or drilling pilot holes and probing with a wire.



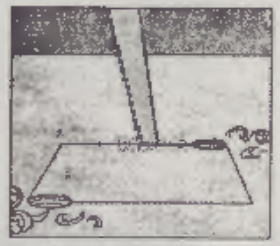
Cut opening between joists to accept the fixture. Secure cable to junction box.



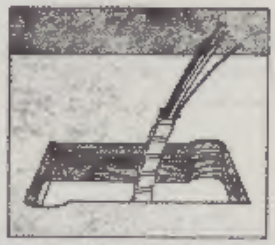
Insert the ceiling fixture box and secure it to the wood strips with screws.

Installing a floor outlet

A floor outlet is convenient because you need not fish wires. Installation is easiest above a basement; the required power for takeoff is usually available from a cable running along or between basement joists. First locate—and avoid—the joist at the installation point by drilling a hole, through basement ceiling and floor above, at each side of joist. The holes mark joist width, so make opening at either side.

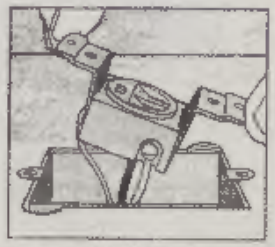


Draw an outline of the box between the floor joists. Drill a clearance hole in each corner and saw out opening.

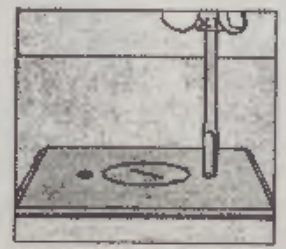


Pull the BX cable through the opening and anchor it to the ceiling below. Strip off armor to expose 4 in. of wire.

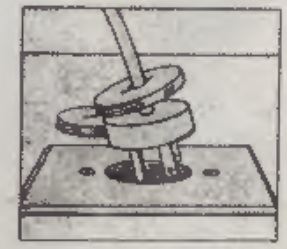
Pass the cable through one of the knockouts in the box and secure with a locknut. Use insulating bushing at cable end.



Screw the box to the floor with flathead screws. Connect black wire to brass screw and white wire to nickel-plated screw.



Install the outlet plate after the receptacle has been bolted to the outlet box. Note dust cover over the plug opening.



Connect other end of cable to power source. Remove cover and insert appliance plug which can take dust protector.

Installation requirements

Outdoor receptacles must be the weatherproof type. They usually have a spring-loaded cover to seal them when they are not in use. The juncture between the cover plate and the wall surface must also be made water-tight with a caulking compound.

Surface-mounted receptacles also have a weatherproof outlet box mounted on the outside face of the wall rather than flush with the wall. Wiring for either type is led to the box through a length of threaded conduit . All wiring to outside outlets must now be protected by a ground fault interrupter (GFI). Grounding and wiring connections are the same as for an indoor receptacle.

Only fixtures and wire approved for outdoor use should be used for outdoor lighting. If the bulb will be exposed to the weather, it should be a weatherproof type to prevent its shattering from contact with rain or snow while in operation.

One type of outdoor lighting fixture is designed to fit a small box in which the connections between fixture wires and supply wires can be made. The box is equipped with a cover and a gasket for protection against rain after the connections have been made.

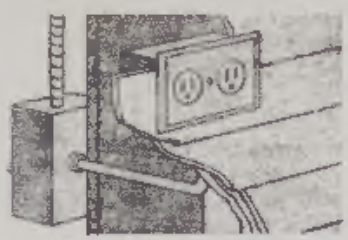
One way to make the wiring passage through the house wall is with conduit (the rigid, threaded type) screwed to the back of the box. If the conduit leads to a grounded junction box inside the house, and is properly connected, it serves to ground the outside fixture. If the conduit merely passes through the wall and serves only as a channel for the cable, the cable must be grounded.

Any tools or appliances that are plugged into an outdoor outlet should be of the grounding or double-insulated type; make certain that their cords are not frayed. Extension cords should be of sufficient capacity that they will convey current to the tool without a drop in the voltage (p. 259).

An outdoor soffit light, such as is shown at the right, can be hooked up with a photoelectric eye to turn the light on at dusk and off at dawn. The bulb is screwed into the photoelectric eye adapter and the adapter is then screwed into the socket. No further wiring is required.

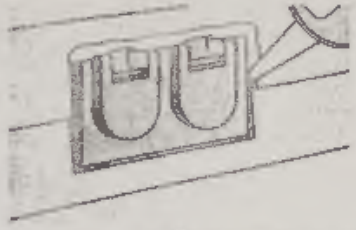
Caution: Before doing any wiring, always make certain that you have turned off the current and that you will be complying with your local electrical code.

Outdoor outlet



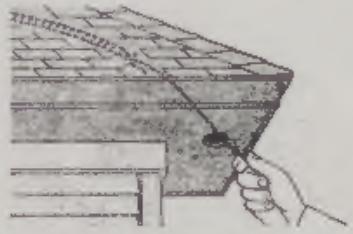
Wire an outdoor receptacle to the nearest junction box in the house. Switch can be used to control outlet.

Cut hole in wall of house to exact size of outlet box. Secure cable; leave 4 in. of wire for connections.



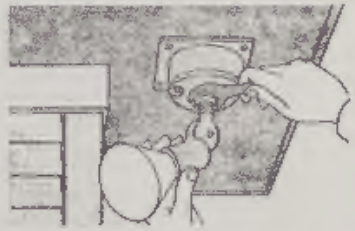
Install the receptacle with weatherproof faceplate. Caulk opening around box to prevent water getting into outlet.

Eave light



Connect cable to power inside house and pass it through a 1-in. hole drilled in the soffit. Work with current off.

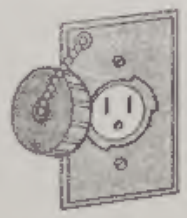
Secure the cable end to special outdoor box with locknut. Allow 4 in. of wire for connections.



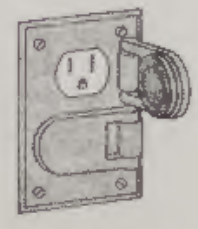
Connect white wire to white wire and black to black. Secure socket assembly with the bolts provided.

Accessories

Switch for outdoor use is especially designed to be weatherproof.



Weatherproof outlets have screw-on caps or spring-loaded lids to protect the openings from the elements.



Special outdoor boxes must be used with outdoor switches, outlets.

Portable outdoor outlet is grounded by third wire in the cord.